

APPENDIX 17.1: ANNOTATED R CODE

```
# Code corresponding to:
# Shiverdecker, L. K., & LeBreton, J. M. (2018).
#   Multilevel (random coefficient) regression
#   modeling.
# In S. E. Humphrey & J. M. LeBreton
#   (Eds.), Handbook of multilevel theory,
#   measurement, and
#   analysis (Chapter 17). Washington, DC:
#   American Psychological Association.

# Step 1: Read in Data File for Multilevel
#   Regression Examples (mlr.csv)
mlr <- read.csv("mlr.csv", header=T, sep=",")

# Step 2: Install packages and load into working
#   library of tools
install.packages("multilevel"); library(multilevel)
install.packages("ggplot2"); library(ggplot2)
install.packages("data.table"); library(data.table)
install.packages("plyr"); library(plyr)

# Step 3: Create function to plot figures 1:4
ggplotRegression <- function (fit) {
  require(ggplot2)
  ggplot(fit$model, aes_string(x =
    names(fit$model)[2], y = names(fit$model)
    [1])) + geom_point() + xlim(0,15) +
    ylim(1,7)+
  stat_smooth(method = "lm", se=FALSE, col =
    "red", fullrange=T) +
  labs(title = paste("R-Square =
    ",signif(summary(fit)$r.squared, 5),
    "Intercept =",signif(fit$coef[[1]],5),
    "Slope =",signif(fit$coef[[2]], 5),
    "P =",signif(summary(fit)$coef[2,4], 5))) +
  labs(x="Trait Aggression", y="Counterproductive
    Workplace Behaviors") }
```

```
#Step 4: Plot Figures
####Create Subsets of Data Used in Figures 1–4
# (note: mlr dataframe was already sorted by
#   GROUP variable)
group1 <- lm(CWB~AGG,data=mlr[01:10,])
group2 <- lm(CWB~AGG,data=mlr[11:20,])
```

```
group3 <- lm(CWB~AGG,data=mlr[21:30,])
group4 <- lm(CWB~AGG,data=mlr[31:40,])
group1234 = lm(CWB~AGG,data=mlr[01:40,])
```

```
####Generate Figures 1–4
ggplotRegression(group1)
ggplotRegression(group2)
ggplotRegression(group3)
ggplotRegression(group4)
ggplotRegression(group1234)
```

```
####Generate Figure 5
all.groups=ggplot(mlr,aes(x=AGG,y=CWB,grou
  p=GROUP))+ xlim(0,15) + ylim(1,7)+stat_
  smooth(method = "lm", se=FALSE,
  fullrange=T) + labs(x="Trait Aggression",
  y="Counterproductive Workplace
  Behaviors")
all.groups
```

```
####Figure 6
groups12=ggplot(mlr[,aes(y = CWB, x
  = AGG)) + geom_point(size = 3, alpha
  = .8) + geom_smooth(method="lm",
  fullrange=T, se= F, size = 1, aes(linetype
  = as.factor(GROUP), group = GROUP))
+ geom_smooth(method = "lm",size =
  3, colour = 'black', se = F, fullrange=T)
+ xlim(0,15) + ylim(1,7)+ labs(x="Trait
  Aggression", y="Counterproductive
  Workplace Behaviors", linetype="Group #")+
  geom_label(aes(label =GROUP),color='blue')
groups12
```

```
#Step 5: Generate the Coefficients in Table 1
set.seed(1)
dat <- data.table(x=mlr$AGG, y=mlr$CWB,
  grp=mlr$GROUP)
OLS = dat[,list(intercept=coef(lm
  (y~x))[1], coef=coef(lm(y~x))
  [2],rsq=summary(lm(y~x))$r.squared)
,by=grp]
OLS
min(OLS[,2]); max(OLS[,2])
min(OLS[,3]); max(OLS[,3])
min(OLS[,4]); max(OLS[,4])
```

```
# Step 6: Multilevel Regression Models
####Null Model(One-Way Random Effects
ANOVA)
# CWB~1, Regressing CWB onto a fixed
intercept
# random=~1 Regressing CWB onto random
intercepts
# |GROUP, Identifies the level 2 variable named
as "group"
# data=mlr Identifies the data set where "CWB"
and "group" are located
Null.Model = lme(CWB~1, random=~1|GROUP,
data=mlr)
summary(Null.Model)

#Estimating the ICCs from the Null Model
VarCorr(Null.Model)
Null.ICC=GmeanRel(Null.Model)
names(Null.ICC) #returns the names of the
variables in the object "Null.ICC"
Null.ICC$ICC #returns the value of the ICC
variable in the Null.ICC object which is the
ICC(1)
Null.ICC$MeanRel #returns the 60 ICC(2)
values corresponding to each group
intercept
#Note: values identical b/c all groups are the
exact same size . . . so sigma^2/nj is the same
for all groups.
mean(Null.ICC$MeanRel) #estimates the mean
across the groups which is the ICC(2) or
ICC(k) [where k = 60]

Null.Model.2=glms(CWB~1, data=mlr)
#Estimating Null Model with Fixed
Intercepts
logLik(Null.Model.2)*-2 #Manually estimating
-2*loglikelihood of Null Models
logLik(Null.Model)*-2
-2*(-805.1175)—2*(-750.5154) #Manually
estimating the difference in likelihood ratios
anova(Null.Model, Null.Model.2) #Manually
comparing fixed vs. fixed + random
intercepts
summary(Null.Model) #Displaying summary of
Null.Model
```

```
VarCorr(Null.Model) #Displaying the variance/
covariance matrix

#### Grand Mean Center the Level 1 Predictor
(NOTE: Not used in this chapter; included
only for illustrative purposes)
mean(mlr$AGG)
mlr$AGG.Grand=mlr$AGG-4.035167
# Aggregate employee-level trait aggression
scores to the group level
AGG.Aggregated=aggregate(mlr[,c(2)],
list(mlr$GROUP), mean, na.rm=T)
names(AGG.Aggregated)
AGG.Aggregated=rename(AGG.Aggregated,
replace=c("Group.1"="GROUP",
"x"="AGG.GroupMean")) #renames
specific variables
names(AGG.Aggregated)
mlr=merge(mlr,AGG.Aggregated,by="GROUP")
names(mlr)

#### Group Mean Center the Level 1 Predictor
mlr$AGG.Group=mlr$AGG-mlr$AGG.
GroupMean
names(mlr)

#Random Coefficient Regression Model
# CWB~1+AGG.group regressing CWB onto
fixed effect for intercept
# random=~1+AGG.group regressing CWB onto
random intercepts and slopes (AGG.group)
# |GROUP, identifying the level 2 (grouping)
variable
# data=mlr name of data file

RCR.Model=lme(CWB~1+AGG.Group,
random=~1+AGG.Group|GROUP,data=mlr)
summary(RCR.Model)
VarCorr(Null.Model) #displays variance/
covariance of parameters from ANOVA
VarCorr(RCR.Model) #displays variance/
covariance of parameters from RCR

#Estimating the ICC_beta from the RCR Model
####NOTE: As of August 9, 2017 the icc_beta
package was not available for version 3.4.0
of R
```

```
#Use gls to estimate model with fixed intercept
  and fixed slope
RCR.Model.2=gls(CWB~1+AGG.
  Group,data=mlr)
```

```
#Use lme to estimate a model with random
  intercept and fixed slope
RCR.Model.3=lme(CWB~1+AGG.Group,
  random=~1|GROUP,data=mlr)
#Test if RCR.Model.3 is a better fit to the data
  than RCR.Model.2
anova(RCR.Model.2,RCR.Model.3)
```

```
#Test if RCR.Model (Random Intercepts &
  Slopes) is a better fit to the data than RCR.
  Model.3
anova(RCR.Model.3,RCR.Model)
```

```
#Intercepts-as-Outcomes Model
#Adding Cohesion as a level 2 predictor
IAO.Model=lme(CWB~1+AGG.
  Group+COH,random=~1+AGG.
  Group|GROUP,data=mlr)
summary(IAO.Model)
VarCorr(RCR.Model)
VarCorr(IAO.Model)
```

```
#Use gls to estimate model with fixed intercept
  and fixed slopes
IAO.Model.2=gls(CWB~1+AGG.
  Group+COH,data=mlr)
```

```
#Use lme to estimate a model with random
  intercept and fixed slopes
IAO.Model.3=lme(CWB~1+AGG.Group+COH,
  random=~1|GROUP,data=mlr)
```

```
#Test if IAO.Model.2 (Fixed Intercept & Slopes)
  is a better fit than IAO.Model.3 (Random
  Intercepts & Fixed Slopes)
anova(IAO.Model.2,IAO.Model.3)
```

```
#Test if IAO.Model3 (Random Intercepts &
  Fixed Slopes) is a better fit original IAO.
  Model (Random Intercepts & Slopes)
anova(IAO.Model.3,IAO.Model)
```

```
#Slopes-as-Outcomes Model
#Testing the cross-level moderating effect of L2
  cohesion on the relationship
###between L1 CWBs and L1 group-mean
  centered aggression scores
#Cross-Product Effect is denoted using “.”
#helping~1+AGG.Group+COH + AGG.
  Group:COH, Fixed coef. for intercept,
  aggression, cohesion, cross-product
#random=~1+AGG.Group Random coefficients
  for intercept and aggression
#|GROUP Name of level 2 grouping variable
  “GROUP”
#data=mlr Data containing variables in SAO
```

```
SAO.Model=lme(CWB~1+AGG.
  Group+COH+AGG.
  Group:COH,random=~1+AGG.
  Group|GROUP,data=mlr)
summary(SAO.Model)
```

```
#Request variance components to estimate
  quasi-R2 for slope variance
VarCorr(IAO.Model)
VarCorr(SAO.Model)
SAO.Rsq=(0.02033669-0.01463884)/
  0.02033669
SAO.Rsq
```

```
#Test whether the remaining variance in slopes is
  significant
SAO.Model.2=lme(CWB~1+AGG.
  Group+COH+AGG.Group:COH,random=
  ~1|GROUP,data=mlr)
anova(SAO.Model.2, SAO.Model)
```

```
# Step 7: Plotting the Cross-Level Interaction
  (Figure 7)
#Descriptive statistics for cross-level moderator
mean(mlr$COH)
sd(mlr$COH)
```

```
#manual estimation of moderator values at +1
  and -1 sd
5.508833 - 0.4758722; 5.508833 + 0.4758722
```

```
mean(mlr$AGG.Group) #estimating mean of
  trait aggression
sd(mlr$AGG.Group) # obtaining sd of trait
  aggression

#creating a new data frame with high-low
  values for (AGG.Group (M; +1SD),
  COH(-1SD; +1SD))
inter.data=data.frame(AGG.
  Group=c(0.0000,0.0000, 1.835865,
  1.835865),
COH=c(5.032961,5.984705,5.032961,5.984705))
inter.data #displaying the data frame

#adding a new variable called "predicted" to
  this new data frame using the 'predict'
  function
inter.data$predicted=predict(SAO.Model,inter.
  data,level=0)
inter.data #confirming new variable added to
  data frame

#plotting the cross-level interaction (Option 1:
  Use the 'interaction.plot' function)
interaction.plot(inter.data$AGG.Group,inter.
  data$COH,inter.data$predicted)
interaction.plot(inter.data$AGG.Group,inter.
  data$COH,inter.data$predicted,
  ylab="Counterproductive Work Behaviors",
  xlab="Aggression (Group-Mean Centered)",
  trace.label="Cohesion")
###cleaning up the plot
inter.data$AGG.Group2=c("0 (Mean)","0
  (Mean)","1.85 (+1SD)","1.85 (+1SD)")
inter.data$COH2=c("-1SD","+1SD",
  "-1SD","+1SD")
inter.data
interaction.plot(inter.data$AGG.Group2,inter.
  data$COH2,inter.data$predicted,
  ylab="Counterproductive Work Behaviors",
  xlab="Aggression (Group-Mean Centered)",
  trace.label="Cohesion")
```

```
#plotting the cross-level interaction (Option 2:
  Use the 'ggplot' function)
ggplot(inter.data,aes(x=AGG.Group2,
  y=predicted,group=COH2)) +
  geom_line(aes(linetype=factor(COH2)))+ #
  Graph separate lines for high and low levels
  of cohesion
labs(title="Cross-Level Moderating Effect
  of Cohesion", x="Trait Aggression
  (Group-Mean Centered)", y="Predicted
  Counterproductive Work Behaviors")+
  scale_linetype_discrete(name="Cohesion")+
  ylim(1,7)
```

```
#Step 8: Concluding Examples
####SEX as level-1 moderator of cwb-agg
####SIZE as level-2 moderator of cwb-coh
```

```
#Specification of Null Model
Null.Model = lme(CWB~1, random=~1|GROUP,
  data=mlr)
```

```
#Specification of RCR
RCR.Model = lme(CWB~1+AGG.
  Group+SEX+AGG.Group:SEX,
  random=~1+AGG.Group+SEX+AGG.
  Group:SEX|GROUP, data=mlr)
```

```
#Specification of IAO
IAO.Model = lme(CWB~1+AGG.
  Group+SEX+AGG.
  Group:SEX+COH+SIZE+COH:SIZE,
  random=~1+AGG.Group+SEX+AGG.
  Group:SEX|GROUP, data=mlr)
```

```
#Specification of SAO
SAO.Model = lme(CWB~1+AGG.
  Group+SEX+AGG.Group:SEX+COH
  +SIZE+COH:SIZE+COH:AGG.Group,
  random=~1+AGG.Group+SEX+AGG.
  Group:SEX|GROUP, data=mlr)
```